MANAGEMENT OF A PATIENT'S PAIN IN A PREHOSPITAL SYSTEM:

USE OF NITROUS OXIDE

Advanced Leadership Issues in Emergency Medical Services

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ABSTRACT

This research project analyzed the efficacy of a nitrous oxide program for field management of pain. The problem was that existing pain medications were not ordered due to a variety of side effects, and that the medication masked the patient's pain, rendering the pain difficult to assess at the emergency department. The purpose of this project was to evaluate the field use of nitrous oxide as an alternative medication for the treatment of pain.

This research utilized both historical and evaluative research to (a) identify the pain medications currently carried by prehospital systems, (b) identify the reasons (side effects) why physicians do not routinely order these pain medications for the treatment of pain, (c) identify alternative medications for the treatment of pain that do not exhibit these side effects, (d) identify the frequency of side effects, if any, with the use of nitrous oxide, and (e) identify the effect that nitrous oxide has on a patient's pain.

The process employed a 50:50 mixture of nitrous oxide and oxygen delivered through a patient self-administered mask. Paramedics then completed an evaluative study sheet to collect data on the frequency of side effects and the measure of pain relief, as described by the patient and observed by the paramedics. Upon completion of a six month study, data was collected to evaluate the effectiveness of the program.

The significant findings of this research was that a majority of patients experienced relief of their pain, while experiencing few, if any, side effects.

The recommendations of this research included the (a) continuation of the use of nitrous oxide as an adjunct to pain management, (b) incorporation of the procedure into the department's operating procedures, and (c) inclusion of the medication into the operating procedures as a standing order, versus requiring physician approval.

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INTRODUCTION

Since the beginning of prehospital medicine, emergency medical service (EMS) providers have long sought an effective method of providing comfort and relief to a patient whose chief complaint, or associated related complaint, may include the complaint of pain. Unfortunately, the variety of medications typically available to treat pain in the prehospital setting include a number of side effects, which often make them contraindicated in prehospital medicine.

The City of Fairfax Department of Fire and Rescue Services recognized this shortcoming in their continued desire to provide optimal quality of services to the customer, including at least a measurable reduction in their pain.

The problem with most commonly used prehospital pain medications is that they typically are not ordered in the field setting due to their actions of masking, or covering up, the chief complaint; and because of the side effects typically seen with the more commonly used narcotics. This lack of field use of pain medication often left the patient in considerable pain as they were transported to the hospital. Given the department's desire to provide optimal quality patient care, including treating the whole patient and their complaint, this "under treatment" was found to be unacceptable.

The purpose of this applied research project was to explore the reasons why pain medications are not routinely ordered in the field setting, and to evaluate the effectiveness of an alternative pain reducing agent, such as nitrous oxide. Developed within the department, the nitrous oxide program was designed to provide a mechanism for paramedics to reduce or eliminate a patient's pain, while reducing or eliminating the side effects typically observed with the use of other more commonly used pain medications. Included in the study would be an effort

to evaluate whether or not the administration of nitrous oxide had any effect on the patient's level of pain, and whether or not there were any associated side effects.

This research project utilized a historical and evaluative methodology to answer the following questions:

1. What are the pain medications typically carried by field paramedics?
2. What are the reasons that the typical pain medications, carried by prehospital advanced life support (ALS) units, are not ordered by physicians in the field setting?
3. What alternative pain medication(s) address the reasons given for not ordering pain medication?
4. What are the frequencies of side effects with nitrous oxide in field administration?
5. To what extent does the administration of nitrous oxide effect the level of pain that a patient is experiencing?

This research project analyzed these questions, and assessed whether or not the use of nitrous oxide in a field setting was a viable adjunct to the inventory of medications carried by paramedics, and whether or not the administration of nitrous oxide had a positive effect on reducing or eliminating a complaint of pain.

BACKGROUND AND SIGNIFICANCE

The City of Fairfax Department of Fire and Rescue Services (Department) is a combination career and volunteer municipal based system of dual role, cross-trained personnel. The Department was created in early 1978 after the City of Fairfax (City) concluded its contract with the surrounding Fairfax County to provide personnel. In the Department's earliest developmental stages, personnel were recruited from across the country to staff the operational

units. Therefore, a significant variety of experience pertaining to patient approach and field treatments were initially brought to the Department at the outset. Currently, the Department consists of 62 career and approximately 30 active volunteer personnel. These career and volunteer personnel staff two engines, one ladder company, two ALS medic units and a duty battalion chief. Three people staff each engine and truck company, while two people staff the ALS medic units. One person covers the position and function of the duty battalion chief. Career personnel are assigned to one of three rotating shifts, working a 56-hour week. Volunteer personnel are utilized to augment existing staffing. Volunteers are recalled to cover for leave and are used in minimum staffing positions on all operational units.

Field medical procedures are delineated through documents known as Operating Procedures (OPs). These OPs are developed, reviewed and approved by the Department's operational medical director (OMD). Included in these procedures is the ability to provide medication to treat a patient's pain. Most medications that are intended to control pain are considered controlled drugs, as they consist of either Demerol or Morphine Sulfate. These same medications also require a physician's approval prior to administration. The difficulty with the current inventory of pain medications is their inherent side effects. Typically, these medications may cause apnea, hypotension, circulatory depression, shock, increases in intracranial pressure, nausea, vomiting, tachycardia, respiratory depression, or decreases in level of consciousness. In addition, they have the inherent ability to mask, or cover up, the symptoms of pain that are seen as essential to proper evaluation and subsequent diagnosis by the receiving physician.

The Department responded to approximately 7,797 calls for assistance during calendar year 1998. Of these emergency responses, over 76% were for EMS assistance. Included in these calls for EMS assistance were patients that had as one or more of their symptoms a complaint of

pain. While the EMS system can provide any number of patient treatment modalities, including airway control, intravenous therapy, electrical defibrillation, and any number of pharmaceutical treatments, most patients are unable to receive any treatment for their complaint of pain. EMS systems can and have continued to provide high quality, state-of-the-art EMS care and intervention. These same systems, including the City, continually deliver the patient to the receiving facility in pain, uncomfortable and with little, if any, treatment being administered that reduces that pain. This inability to reduce a patient's level of pain has a direct correlation to their mental and physical outcome, and how they perceived the quality of EMS care that was delivered.

In the National Fire Academy's Executive Fire Officer course, entitled "Advanced Leadership Issues in EMS," one of the principals upon which this course was based was looking at all components of the EMS system and searching for dynamic, cutting edge ways to provide high quality EMS care. The principals upon which this class was based were instrumental in completing the necessary research, program development and implementation of the nitrous oxide program within the Department.

While a patient may report a complaint of pain as either the primary complaint, or associated with other complaints, the customary avenues of pain relief are often not applicable or approved by medical control. The administration of the typical pain medications masks the pain so that the receiving physician has difficulty assessing the nature, cause and extent of that pain. In addition, most of the pain medications typically administered have significant side effects, which during the short time the patient is with EMS, crews render them as a relative contraindication to good patient care. Alternatives were sought by the Department to provide a more comprehensive method of total patient care, including the ability to deliver the patient to

the receiving emergency department either pain free, or at least reducing the pain to a more tolerable level.

LITERATURE REVIEW

Pain is a most uncomfortable sensation, one which prehospital providers often try to reduce or eliminate. According to Stedman's Medical Dictionary, pain is defined as "an unpleasant sensation associated with actual or potential tissue damage, and mediated by specific nerve fibers to the brain where its conscious appreciation may be modified by various factors" (1990, p. 1122). "Pain has been on the human mind for millennia. And acute pain is the single commonest reason both for seeking medical care and for taking medication" (Paris, 1996, p. 66). Most EMS systems, both prehospital and receiving facility, experience patient encounters that have some complaint of pain. "Pain is a leading reason for patient visits to the emergency department" (Walsh, 1993, p. 1176). "EMS providers interact with patients in pain daily. Pain is the most common reason patients seek medical attention" (Paris, Phrampus, 1999, p. 34). Certainly, EMS systems are no strangers to this complaint. "Emergency medical systems are activated for very few reasons. Any experienced dispatcher can tell you that the emergency phone call is placed, with very few exceptions, for one reason: someone in pain" (Ballinger, 1979, p. 14).

However, according to Paris, et al., "studies show that patients consistently receive inadequate doses or no pain control during their interaction with the medical community" (1999, p. 34). Early management of pain is important to comprehensive patient care.

Wexler (1987) describes the pain process and the importance of interrupting the pain cycle:

> Pain precipitates the release of catecholamines, hormones such as epinephrine, norepinephrine and dopamine. If the dangerous cycle of pain-anxiety-increased oxygen demand-increased pain-increased anxiety-increased oxygen demand is not broken, the patient will slip deeper and deeper into shock due to inadequate tissue perfusion. (p. 20)

One must understand, however, that it is not the goal of EMS providers to completely eliminate the pain. "The goal of initial pain management is not to extinguish pain, but to reduce the pain perceived by the patient to a tolerable level without causing serious side effects" (Paris, et al., 1999, p. 34).

"Prehospital providers may harbor concerns that aggressive pain management will delay or prohibit an accurate diagnosis by a receiving physician" (Paris, et al., 1999, p. 34). Those concerns, as well as the side effects of pain medications, are certainly shared by the receiving physician. Stewart (1985) describes the following:

> We are particularly limited in prehospital care as to how vigorous we can be in the use of analgesic drugs. Should side effects of pain medication occur, the field environment is not the ideal setting for correction of such problems. In addition, we must consider the possibility of masking symptoms which would make in-hospital diagnosis and definitive care more difficult. (p. 139)

"On the one hand, the provision of pain relief to the patient can be decidedly beneficial. On the other hand, the use of analgesic agents, particularly in the uncontrolled field setting, carries risks which must be weighed in light of the benefits provided" (Stewart, 1985, p. 139).

It is for these reasons that the prehospital use of pain medication is so infrequently ordered. "A recent survey of ALS systems revealed that less than 25 percent of EMS systems carry analgesics other than morphine sulfate, which is typically utilized only for ischemia-natured cardiac pain" (Leduc, Paris, 1996, p. 75). In some instances, this undertreatment continues into the emergency department. "Wilson and Pendelton found that 111 (56%) of 198 patients admitted to the hospital with painful conditions received no analgesic in the emergency department" (Paris, 1996, p. 66). In comparing the list of drugs currently used in the field setting today, many are not ordered for a variety of reasons. "Narcotic agents such as morphine and Demerol are the usual tools we work with, both in the prehospital phase of treatment and in the emergency department" (Ballinger, 1979, p. 15). "The opioids, classically morphine and fentanyl, are the mainstay medications for pain relief in mainstream medical care. In the field, morphine sulfate is often the only drug for analgesia that units carry" (Paris, et al., 1999, p. 39). Ballinger describes the primary issues surrounding the infrequent orders for field administration of pain medication:

> Some of the undesirable characteristics are: narcotics must be injected; there is a 15 minute delay in onset of action; narcotics are long-lasting (four hours); side effects such as respiratory depression, cardiovascular depression, nausea and vomiting, changes in pupillary status, and occasionally cardiac dysrhythmia. (p. 15)

"Fear of the drug's potential for side effects – including respiratory depression, nausea, vomiting and hypotension – prevents many systems from using it for other types of pain control" (Paris, et al., 1999, p. 39).

In order to provide for optimum pain management, an alternative was needed that addressed these most commonly encountered side effects, did not leave long lasting masking effects, and was easily administered. Certainly, there are additional field treatments that can and should be utilized in addition to pharmacological intervention. According to Leduc, et al., (1996):

> Pain management should be an objective for all levels of EMS providers. All EMS providers must realize that pain can and should be managed at the earliest opportunity possible. This premise should be kept in mind and can begin with basic pain-relieving interventions, such as placing a patient in his position of comfort and maintaining an understanding and compassionate demeanor. Early basic interventions may provide significant pain relief and comfort to patients. (p. 76)

While certainly important to overall patient management, additional treatments were needed that provided pain relief. The use of nitrous oxide has in fact been in use for centuries. "The young man, Humphrey Davy, became interested in the properties of the newly discovered gas nitrous oxide. After several years, he reported the results of his observations in a book published in 1800" (Stewart, 1985, p. 135). Many years have passed since that first discovery and many improvements have been made that have rendered this gas safer for use. Stewart also describes the history of the development of nitrous oxide:

> Borrowing from the extensive experience in obstetrical patients, Peter Baskett, an anesthetist from Bristol, in 1969 utilized a mixture of 50% nitrous oxide and 50% oxygen in the ambulance service. Following this clinical trial of prehospital analgesia, he concluded that a self-administered 50:50 mixture is a safe and effective analgesic agent for emergency care. (p. 140)

In searching for an alternative, a medication was needed that did not include the masking of symptoms, as found with the narcotic agents. "On the basis of this and other investigations, nitrous oxide in a 50:50 ratio with oxygen appears to be a safe and effective analgesic agent for the relief of pain in both the prehospital and hospital administration of emergency medicine" (Ballinger, 1979, p. 15).

More recently, other EMS systems have explored the use of nitrous oxide as a pain management tool. "In Hillsborough County, Florida, the indication for nitrous oxide administration outside the hospital is simple: relief of pain" (Ballinger, 1979, p. 15). "One study (conducted in Pittsburgh) of more than 3,000 patients found the use of nitrous oxide in the field safe and effective" (Paris, et al., 1999, p. 40). While nitrous oxide has been available to other medical professions for many years, the ability to provide this medication in a safe and effective portable device has limited its field use. "In the last 10 years, with the development of a portable delivery system, nitrous oxide became available for use in the prehospital setting" (Johnson, Atherton, 1991, p. 45).

It is important to point out at this juncture that the use of a nitrous oxide mixture provides for analgesia, not anesthesia. Stedman's (1990) defines an analgesic agent as "a compound

capable of producing analgesia, i.e. one that relieves pain by altering perception of nociceptive stimuli without producing anesthesia or loss of consciousness" (p. 65).

By contrast, Stedman's defines an anesthetic agent, such as general anesthesia, as the "loss of ability to perceive pain associated with loss of consciousness produced by intravenous or inhalation anesthetic agents" (p. 76). To further clarify, Stedman's defines nociceptive as "capable of appreciation or transmission of pain" (p. 1056).

The ability to provide for the complete management of a patient's chief complaint, including the complaint of pain, is tantamount to providing a comprehensive, high quality system of emergency medical care. The current medications typically provided to an EMS system to deal with a patient in pain, namely morphine sulfate and Demerol, have consistently been described as having significant side effects that, in general, do not warrant their field use. The literature describes many systems that have been utilizing a mixture of nitrous oxide and oxygen for the field management of pain. These same systems describe the benefits of the field administration of nitrous oxide, while limiting or eliminating the side effects typically seen with other pain medications. It is these studies, and those systems that carry nitrous oxide, that positively influenced the Department to explore the field use of a nitrous oxide and oxygen delivery system for the field management of pain.

PROCEDURES

The determination of whether or not to begin an evaluation of the efficacy of a nitrous oxide program began with a conversation with the Department's operational medical director (OMD). The author, serving in his role as the administrative battalion chief in charge of the EMS program for the Department performed this conversation. This conversation entailed the

exploration of the history of pain medication and the frequency of medication orders for department units responding to EMS incidents.

An evaluation of incidents during calendar year 1998 revealed the frequency of incidents in which a complaint of pain was described by the patient (Table 1).

TABLE 1

Responses to EMS Emergencies: Calendar Year 1998

Unit	Responses	Number of reported complaints of pain
Medic Unit 403	3107	1180 (38%)
Medic Unit 433	2821	1075 (36%)

Additionally, an evaluation was completed and presented to the OMD regarding the frequency of pain medication administration for complaints of pain. A limitation of the data was the inability to assess the frequency of requests for pain medication versus the approval by medical control for pain medication. This data is not currently collected as part of the minimum data set for EMS reports. Of the 2,255 reports of patients whose chief complaint included one of pain, only 496 patients (22%) received orders to administer pain medication. Of those incidents, the pain medication carried by city units, and approved for patient administration, included either morphine sulfate or Demerol. These were the only medications carried at that time for the relief or control of pain.

A review of the generally understood reasons for not approving, or requesting, the administration of pain medication, with the OMD, also revealed his concurrence of the data and positions held by the literature. It was the OMD's opinion that the literature and his experience

validated the reasons for not ordering pain medication in the prehospital setting, except for very limited situations.

In the early discussions with field providers within the system, it was apparent that they shared the concern regarding the field administration of pain medication currently carried by City units. However, they also shared with the author their concern that many patients were not receiving appropriate levels of pain relief due to the infrequency of orders for pain medication. In addition, the EMS providers felt that they were not providing optimal patient care if the patient was still experiencing pain both during the field treatment and upon arrival at the emergency department. These discussions were held in an informal setting, both to involve the providers in information gathering and to solicit ideas on the best approach to take with respect to program development.

With this information in hand, the author explored the idea of a nitrous oxide program with the OMD. It was at this point that the OMD approved the development of a pilot program for the field use of nitrous oxide for pain relief.

In order to develop a comprehensive program, several components of the overall program were identified. First, a supplier of a portable, reusable nitrous oxide and oxygen system was sought. After extensive research into EMS suppliers, a single supplier was identified. This vendor was selected because there were no other vendors that carried this type of a device. Matrx Medical, Inc., from Orchard Park, New York, had such a system. The system incorporated a portable unit that consisted of a small bottle of nitrous oxide and a mixing valve that connected to either an on-board or portable oxygen system. This mixing system enabled the user to deliver a 50:50 mixture of nitrous oxide and oxygen, known as Nitronox®. The complete

system was incorporated into a small carrying case, which was enclosed within a zippered bag, and was secured by a break-off plastic lock.

A process was then identified to replace or refill the nitrous oxide bottle after use. In exploring the alternatives, it was determined that the easiest process for refilling the nitrous oxide cylinder was to reorder bottles from the supplier. The bottles would be ground shipped upon receipt of an order, and the empty cylinders would be returned for credit. This process was easier, and in fact, would take less time since all regional compressed gas suppliers indicated they shipped these bottles out for refilling. This process would take in excess of 3 - 4 weeks, as compared to the 7 - 10 day period for receipt of ordered cylinders. Since the nitrous oxide bottles did not incorporate a gauge to determine remaining capacity, a system was developed to measure the remaining gas. First, a short form was developed (Appendix A) that would provide the user with a mechanism to document the number of time nitrous was administered and the approximate duration of gas administration. According to the information supplied by the vendor, each bottle would provide approximately 30 minutes of gas administration. For safety, and to ensure that sufficient gas remained for the next patient encounter, each bottle had to be replaced after each 20 - 25 minutes of use. Secondly, as an additional safety measure, the new bottles were weighed to determine their full weight. A small postal type scale was purchased, and as each bottle was used the weight decreased. The EMS providers were able to determine, by the documentation of usage and the actual weight, when the bottle needed to be replaced.

Accountability of this medication was determined to be important. Since there was a possibility that this gas could be abused, a locking device was utilized that provided a small level of security. Using a small plastic tab lock, the Nitronox® bag was secured to prevent

unauthorized access. The paramedic ensured the accountability of the nitrous oxide each day at shift change by a notation in the station logbook, pursuant to a departmental operating procedure.

The next step entailed an educational class for all ALS providers. Since this was a new concept and medication that would be carried by City units, an overview was provided as an instructional tool. Information about the medication, its uses, indications, contraindications, side effects, etc. was included as part of the training (Appendix B). All ALS providers were required to read the bulletin and become familiar with this medication, and each shift EMS captain ensured that compliance. Once all ALS personnel had completed the necessary familiarization, the medication was placed on each of the two City EMS units. Since this program was limited for use to only ALS providers, the educational components and did not include the department's basic life support (BLS) providers.

Since the program would entail a request from the hospital to use the medication, all surrounding emergency departments, and the chairperson of each emergency department, was advised of this additional medication through a formal letter from the department. The emergency departments were limited to only those which our units could conceivably transport patients. No other facilities were advised of this protocol change.

In order to validate the program, and to actually determine whether or not the field use of nitrous oxide would prove beneficial, a quality assurance mechanism was developed to collect data. This form, known within the Department as a study sheet, would be required to be completed upon each patient encounter in which the medication was ordered (Appendix C). All patients in which nitrous oxide was requested would be evaluated. An evaluation would be completed between the frequency of requests versus the number of times that the medication was administered. This comparison would indicate whether or not any physicians at receiving

emergency departments were refusing to approve the administration of the medication. During the study period, no such instances occurred.

The completed study sheet, along with a copy of the Department's run report, would be forwarded to the administrative battalion chief for review and data compilation. This data would be collected throughout the study period and discussed with the OMD on a periodic basis. The study period would last six months. The administrative battalion chief felt, with concurrence by the OMD, that this period of time would be sufficient to collect enough data to be statistically significant. Based upon this data, a determination would be made at the conclusion of the study period on whether or not the field use of nitrous oxide was beneficial to patient care. This determination would be made based on the (1) frequency of requests, (2) frequency of administration, (3) extent of side effects to the administration of the medication, and (4) amount of pain relief noted by the patient.

To assist the paramedic in the evaluation of this subjective information on pain relief, a grading scale was developed within the study sheet. In performing the assessment of the patient, a grade was assigned to the level of pain, both as evaluated by the paramedic and as described by the patient. Objective criteria were established to assist in the assignment of this grade. The grades ranged from "0" through "4", with "4" being the most severe. A grade of "0" was defined as no complaints. A grade of "1" was defined as "mild," meaning the patient was calm, and complains only when asked, and the patient did not complain of any nausea, vomiting, pallor or diaphoresis. A grade of "2" was defined as "moderate," meaning the patient complains of pain spontaneously, but still did not have any complaint of nausea, vomiting, pallor or diaphoresis. A grade of "3" was defined as "severe," meaning the patient groans, bitterly complains, and nausea, vomiting, pallor or diaphoresis may be present. A grade of "4" was defined as "very severe,"

meaning the patient groans, writhes, screams, and nausea, vomiting, pallor and diaphoresis is usually present.

RESULTS

Development of the program proposal to the OMD consisted of a literature review and telephone survey of all surrounding EMS agencies within the Northern Virginia area. In this review, information was sought to determine which medications were carried by ALS units to treat pain. This information correlated to research question #1. The literature revealed that most EMS systems carried morphine sulfate and Demerol for the treatment of pain. A telephone survey of all agencies within the Northern Virginia area revealed that these agencies carried morphine sulfate and Demerol. These specific agencies were selected due to the regional mutual aid agreements in place. Agencies outside this immediate area, which did not have existing mutual aid agreements in place, were excluded from this survey.

An evaluation was then completed to determine the reasons why the existing pain medications were not routinely ordered for field use. Research question #2 was explored to evaluate why physicians did not order the administration of the typical pain medications in the field. This information, supported by the literature and by discussions with the Department's OMD, concluded that there were typically two reasons why physicians did not routinely approve or order the administration of pain medication in the field. These reasons could be grouped into one of two categories: (1) Pain medications typically cover, or mask, the pain. This phenomenon made it extremely difficult for the receiving physician to evaluate the pain once the patient arrived at the emergency department; or (2) Pain medications cause a variety of side effects. These side effects are felt to outweigh the potential benefits of pain control. Side effects

generally include nausea, vomiting, respiratory depression, hypotension, cardiovascular depression, and cardiac dysrhythmia.

Research question #3 was designed to identify other alternatives to pain medication that may be available for field use. Any new medication had to have fewer side effects than the medications currently in use. It had to be easy to administer, and should not be long lasting. In reviewing the literature, a mixture of nitrous oxide and oxygen, delivered in a self-administered fashion, was determined to be the ideal medication for the field management of pain. Nitrous oxide and oxygen, while having some possible side effects, was determined to be a valuable adjunct to prehospital ALS personnel to treat a patient in pain. Nitrous oxide's mechanism of action include serving as a central nervous system depressant, providing analgesic properties, increasing available oxygen to the tissues, and having a short onset of action. In addition, since the medication is delivered in a gas and has a short action time, as soon as the gas is removed, or the patient stops breathing the gas mixture, the effects of the nitrous oxide dissipate quickly. This provided the added benefit of removing the "masking" associated with the other pain medications currently carried by EMS units. Side effects associated with the administration of a nitrous oxide mixture include drowsiness, dizziness, vertigo, numbness, nausea and vomiting, excitement, headache, and also some reported amnesia effects. The literature revealed that these side effects are reported in a small percentage of the cases, and are quickly eliminated once the gas mixture is removed. It was with this information that the City fire and rescue, in conjunction with the OMD, determined that the trial use of nitrous oxide was warranted and needed further study.

In performing the study, ALS units from the City delivered a 50:50 mixture of nitrous oxide and oxygen in a patient self-administered fashion to patients who fit into the category of

potential recipients of the gas. Indications for the use of this medication would include musculoskeletal pain, burns, suspected ischemic chest pain, states of severe anxiety, fractures, dislocations, sprains and strains, and soft tissue injuries. During the study period, a total of 33 reported cases of nitrous oxide administration were processed for review. While somewhat low in number, the results were determined to be substantial enough to warrant this data to be significant.

An evaluation of the data supplied from the study sheets included: (1) demographic information on the patient's age, (2) sex, (3) chief complaint, (4) side effects, (5) position of the patient when the gas was administered, (6) length of time the gas was administered, (7) amount of time before relief from pain was noted by the paramedic, and (8) an evaluation of the degree the pain was relieved.

Of the reported 33 cases, the mean age of the patient was 39.7 years, with a range of ages from 15 to 77 years. This data was further defined as the mean age for men being 38.7 years (range between 15 and 77 years); and the mean age for woman being 37.6 years (range between 18 and 77 years). The administration of nitrous oxide was dispersed between men and woman as follows: 24 men (73%); and 9 for woman (27%). Clearly, the sample population was weighted toward men, as compared to women. The age range and mean age of the patient, however, was extremely close.

In evaluating the data, the patient's chief complaint was reported, and the frequency of each is reflected in Table 2.

TABLE 2

Reported Chief Complaints

Chief Complaint	Frequency	Percentage of complaints
Fracture	14	42%
Soft Tissue Injury	2	6%
Sprain, Strain	3	9%
Back pain	8	24%
Chest pain	3	9%
Other pain, not defined	6	18%

Note: Some patients had more than one type of complaint of pain.

In this portion of the study, the primary chief complaint of patients was either fractures or back pain.

An evaluation of the data also included information regarding the report of any side effects from the administration of the nitrous oxide. This data directly related to research question #4 regarding the frequency of reported side effects of nitrous oxide in field administration. The data is shown in Table 3.

TABLE 3

Reported Side Effects

Type of side effect	Noted before gas administration	Percentage of cases (before gas administration)	Noted after gas administration	Percentage of cases (after gas administration)
None	27	82%	18	55%
Nausea	3	9%	3	9%
Vomiting	1	3%	1	3%
Dizziness	1	3%	3	9%
Excitement	0	0	0	0
Lightheadedness	1	3%	5	15%
Other*	0	0	5	15%

* Includes minor parasthesias, improved disposition and increased pain tolerance.

Note: Some patients had more than one side effect noted.

While there was a reduction in the category of patients with no side effects, as compared with "prior to gas administration" and "post-gas administration", very little increase was observed in any of the other categories of side effects, with the exception of a slight increase in reports of lightheadedness, and "other" side effects. As noted above, the "other" category also included patients that exhibited an improvement in their overall disposition, and increased pain tolerance, meaning they complained less and tolerated the pain better than before the administration of nitrous oxide. Important to note was that the majority of patients had no reported side effects whatsoever.

Additional data collected in the study included an evaluation of the position that the patient was in when the gas was administered. This data was collected to determine whether or not the position the patient was in had any effect on the potential relief from nitrous oxide administration, as noted by the patient. This data is shown in Table 4.

TABLE 4

Patient Position During Administration

Position of patient	Frequency	Percentage of patients
Supine, flat	7	21%
Prone	0	0%
Sitting	26	78%
On their side	0	0%

This data did not indicate any specific relevance to pain relief.

Accumulation, and evaluation, of data regarding the overall amount of time that nitrous oxide was administered revealed a range of time from 1 - 20 minutes, with the mean time being 7.78 minutes.

Data collected, however, on when pain relief was noted by the patient, ranged from 1 - 17 minutes, with the mean time being 3.28 minutes. This data indicates that relief of pain was noted in just over 3 minutes.

An overall evaluation of the data collected as a result of the study, and pertaining to research question #5, revealed the following:

1. In 6 cases, or 18%, the patient reported no pain relief from the administration of nitrous oxide.
2. In 12 cases, or 36%, patients reported the pain decreased one level, according to the grading scale developed for the study.
3. In 11 cases, or 33%, patients reported the pain decreased two levels, according to the grading scale developed for the study.
4. In 4 cases, or 12%, patients reported the pain decreased three levels, according to the grading scale developed for the study.
5. Overall, 27 patients, or 82% of the patient population studied, reported a decrease in the level of pain with the administration of nitrous oxide and oxygen.

DISCUSSION

In analyzing the data from the study, and comparing it to the information contained in the literature, it was clear that the results from the limited study performed in the City were consistent with other studies on the use of nitrous oxide. Stewart, in 1985, described the use of nitrous oxide as an alternative for pain management in prehospital systems. Earlier studies in Tampa and Hillsborough County, Florida indicate the positive benefits of nitrous oxide, as described by Ballinger in 1979. Stewart, in 1985, describes the earliest use of nitrous oxide by a

young chemist late in the eighteenth century. This medication, in the form of a gas, has been in the medical community for centuries. These studies clearly demonstrate the efficacy of administering a nitrous oxide and oxygen combination in a patient self-administered fashion.

It is the author's opinion that the results of the study, completed in the City, indicate a use for this medication. The side effects, when seen at all, are relatively minor. A majority of the patients describe at least some relief from the pain associated with their medical complaint. The relative onset of action, and subsequent relief, is quick. Of equal benefit, although most patients did not care for this resulting action, was that the effect of the medication quickly dissipated once the medication was removed. This result often led the patient to ask the paramedics to place them back on the nitrous oxide even in the emergency department.

The results of the study, as confirmed by the various studies found in the literature, indicate the benefit of adding nitrous oxide to the armament of medications carried by paramedics. The initial and ongoing costs, associated with the purchase of the equipment, are relatively minor when compared to the fact that the majority of patients delivered to the emergency department had some pain relief.

The implications to the Department are quite clear. Through the judicious use of a mixture of nitrous oxide and oxygen, paramedics can provide a more comprehensive level of patient care and treatment. This high quality level of care can be performed with little risk and few side effects. The costs are minimal, and the impressions left on our customers form a lasting image of the care, compassion and quality of service delivered to the community.

RECOMMENDATIONS

It is the recommendation, as supported by the study results, that the use of nitrous oxide as a pain management adjunct continue. The use of this medication directly effects the reasons that pain medications are not typically ordered in prehospital systems. Nitrous oxide has few side effects, does not mask the pain associated with the patient's chief complaint, is easily administered, does not require the medication to be injected into the patient, thereby causing additional pain, and is relatively inexpensive.

To fully assimilate the use of nitrous oxide into the organizational culture, it is recommended that the operational procedures for EMS include the use of this medication into the treatment plan. All protocols that outline the field treatment of pain should now incorporate the use of nitrous oxide. Additionally, since the study of nitrous oxide has been so successful, discussions should be held with the OMD to include the use of nitrous oxide as a standing order, as compared to requiring physician approval for each patient. In this way, paramedics can begin treatment to relieve pain quickly, thus eliminating the need for physician approval.

It is certainly important to evaluate a program such as this to determine its appropriateness, efficacy and to obtain results. However, the results of the City's study were consistent with those of other organizations that have completed similar studies. The use of a nitrous oxide and oxygen mixture, delivered in a patient self-administered fashion, within the guidelines and indications of use for the medication, has consistently shown to benefit the patient. The medication is easily administered, the side effects are limited and minor in nature, and varying degrees of pain relief has been accomplished. If organizations are truly interested in providing high quality patient care, certainly pain management is paramount to addressing our

total patient's needs. Whether it is through additional studies, or relying upon the work of others, EMS systems should aggressively evaluate the field use of nitrous oxide as a pain management tool.

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APPENDIX A

City of Fairfax
Department of Fire and Rescue Services

Nitrous Oxide Cylinder Use Log

Cylinder Number: _____

DATE	AMOUNT USED (MINUTES)	PARAMEDIC INITIALS

NOTE: Cylinders are rated at 30-minute capacity. Return used bottle to the supply closet for replacement after approximately 20-25 minutes of elapsed patient use.

APPENDIX B
Nitrous Oxide Use Informational Bulletin

Type of Medication:

Analgesic

Known Medication Actions:

Mild sedation
Anxiolytic
Mild to moderate analgesia/increases pain threshold
Weak anesthesia
Mild dissociative effect

Physical Properties:

Colorless, "sweet" smelling gas. Liquefies when compressed. Non-flammable, Non-explosive, will support combustion.

How Supplied:

30 minute, single patient use cylinder packaged with oxygen mixer device and demand valve with patient mask or mouthpiece.

Indications:

Administered only under direct physician orders to relieve pain or anxiety associated with:

1) Isolated trauma
    burns
    fractures
    dislocations
    soft tissue injuries
2) Acute abdomen
3) Back pain
4) Extremity pain
5) Kidney stone pain
6) Chest pain uncontrolled by other intervention
7) Other pain not specified that is not otherwise contraindicated
8) Labor pain beyond first trimester

Contraindications:

1) Multiple system trauma
2) Altered mental status
3) Decreased level of consciousness
4) Sedated or intoxicated patients
5) Severe maxillofacial injury
6) Hypotensive patients
7) Pneumothorax or tension pneumothorax
8) Bowel obstruction or abdominal distention
9) COPD patients
10) Decompression sickness (bends)
11) First trimester pregnancy
12) Severe head injury
13) Inability of patient to follow or understand instructions (consider language barriers)
14) Any patient who is otherwise hemodynamically unstable
15) Any pediatric patient who is not old enough to hold the mask/mouthpiece to his/her face on their own

Dose and Route:

Patient should be preoxygenated with at least six (6) lpm for two (2) minutes prior to administration. This has been shown to decrease the needed dose of nitrous. A mixture of 50% nitrous and 50% oxygen is then inhaled by the patient. Nitrous is only to be self-administered by the patient using the demand valve combined with mask or mouth piece. Onset should take 2-5 minutes. Medication should be continued until patient drops the mask or mouthpiece or until the pain has been significantly relieved or detrimental side effects develop.

Possible Side Effects:

1) Drowsiness
2) Dizziness/light-headedness/vertigo
3) Numbness
4) Amnesia
5) Nausea/vomiting
6) Giddiness/excitement
7) Headache

Special note: May cause apnea if not self-administered

Special Information:

1) Must be administered in well vented area -- vehicle windows should be open and exhaust fan should be utilized.

2) Cylinders should be kept in sealed carrying case and stored in an upright position. Cylinders should also be kept closed when not in use. Inverted *open* cylinders may leak, causing "freeze burns" to exposed skin.

3) Prior to patient use, *closed* cylinder should be inverted six (6) times before use.

4) If colder than 50 degrees fahrenheit, *closed* cylinder should be inverted six (6) times before use.

5) For more information, providers should read and understand unit instructions and attend in-service class prior to use.

6) Carrying case must be kept secured with plastic lock at all times. Once seal has been broken for patient use, partial or empty bottles should be returned to the administrative battalion chief. Replace used cylinders with full bottle, and secure carrying case.

7) Control and accountability of nitrous oxide will be handled as a controlled substance, including documentation and notification requirements.

8) Pediatrics (age parameters): nitrous oxide will not be administered to a patient who is not old enough to hold the mask/mouthpiece to his/her face on their own.

9) High doses of Narcan (2.5 - 20 mg/kg) **may** reverse the effects of nitrous oxide.

APPENDIX C

CITY OF FAIRFAX FIRE AND RESCUE SERVICE
NITROUS OXIDE ANALGESIA
Data Sheet

Event #_____ **Medic 3** **Medic 33** **A B C**

Pt. Name: **Date:**
Chief Complaint (circle one): 1 Fx/Dislocation 2 Soft Tissue Injury 3 Strain/Sprain
4 Burns 5 Back Pain 6 Chest Pain 7 Labor Pain 8 Other Pain (explain)
AGE: **SEX: M F**
Allergies: **Medications:**
Other Analgesia/Procedures/Drugs:

Parameter	Before	After	In E.D.
Resp. to voice	Y N	Y N	Y N
Resp. to pain	Y N	Y N	Y N
Pulse (rate)			
B/P			
Respirations			
Gag reflex	Y N	Y N	Y N
EKG:(if taken)			
Grade of pain: Patient:[1]			
Paramedic:[1]			
Side Effects:[2]			

[1] **0: NONE: no complaints**
1: MILD: calm, complains only when asked; no nausea, vomiting, pallor, diaphoresis present.
2: MODERATE: complains spontaneously; no nausea, vomiting, pallor, diaphoresis present.
3: SEVERE: groans, bitterly complains; nausea, vomiting, pallor, diaphoresis may be present.
4: VERY SEVERE: groans, writhes, screams; nausea, vomiting, etc. usually present.

[2] **N: Nausea V: Vomiting D: Dizzy E: Excitement S: Sleep**
L: Lightheadedness O:Other (explain)_____

Did the patient have any difficulty using the mask/mouthpiece?

_____

_____

In what position was patient when gas was administered? 0: supine, flat; 1: prone 2: sitting 3: side

TIME OF NITROUS ADMINISTRATION:_____**am/pm**

TIME RELIEF NOTED: _____ **am/pm**

TOTAL TIME OF NITROUS ADMINISTRATION: _____ **minutes**

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INSTRUCTIONS TO PATIENT: "We are going to give you some oxygen with a medication in it that will help with your pain. Hold the mask/mouthpiece on firmly and breath normally. You will hear a "hiss" as the gas mixture flows through the mask. There is no need to overbreathe. Try to relax, you may feel a bit "numb" and drowsy, this is normal.

ALS CREW TIPS: Don't overstimulate the patient while the gas is being given. Ensure that there is a tight seal between the mask/mouthpiece. Have the patient lie still and not talk.

...ATTACH CAD RUN REPORT...